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FATAL AND SEVERE INJURY MOTOR VEHICLE CRASHES INVOLING AIR FORCE PERSONNEL

1988-1999

by

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Preface

Vehicle crashes are common. Almost every surviving adult has been touched by vehicle crash tragedy. In hindsight, nearly every event was preventable. This project presented a great opportunity to look at the severe crash experience of a special population – the men and women of the United States Air Force. It was also a perfect opportunity to give something back to the Air Force safety community, whose meticulous investigation, reporting, and data storing process is often under appreciated.

My gratitude goes to personnel at the Air Force Safety Center for use of vehicle crash data. First and foremost, thanks go to Col Robert Scott, Policy, Research and Technology Division Chief, and my former boss. He is a staunch supporter of mishap prevention research endeavors. Thanks also go to Lt Col Julie Robinson and Maj Maggie Meigs for their help with the parent data file. I would also like to thank Col Rick Hersack, chair to the Air Force Surgeon General at the Air War College, for his interest in ensuring safety and health promotion and injury and mishap prevention issues become integrated into various Air University curricula. Finally, I thank Lt Col James Quattlebaum for his help and patience as my faculty research advisor. I certainly recognize my good fortune in having him behind me on this project; to him I am most grateful.

Abstract

Motor vehicle crashes are the leading cause of death, and their malevolent predilection for the young is particularly daunting. The men and women of the United States Armed Forces are not spared from this cruelty, where vehicle crashes take more of their lives than any other cause, including combat training and battle injury. This study quantifies, for the first time, factors associated with motor vehicle crashes that left Air Force personnel permanently disabled or killed. It also compares select crash factors to those affecting the United States general population. This project found vehicle crash fatality among Air Force personnel consistently and significantly lower than – just fifty to sixty percent of – the United States general population from which they came. Credit is given to the higher prevalence of safety belt use, and military service itself. Risk reduction opportunities were also evident, and include the commonly reported factors of alcohol impairment, speeding, misuse of occupant protection, and nighttime and weekend travel – particularly among youthful males, and especially when the latter were driving. Most intervention opportunities appear particularly vulnerable to three public health initiatives rightfully gaining popularity in the United States. These are lower blood alcohol limits, graduated driver licensing, and nighttime driving curfew. In light of this study, the Air Force, indeed the Armed Forces, must consider implementation of tailored versions of these initiatives to further reduce vehicle crash morbidity and mortality. Other intervention opportunities not addressed by these initiatives are also presented for safety awareness.

Chapter 1

Purpose

A tragedy means always a man's struggle with that which is stronger than man.

—G. K. Chesterton

Motor vehicle accidents are the nation's most common and costly serious injury producer, and rob the young in particular of the most productive years of their lives. Motor vehicle crashes (MVCs) in the United States claim over 41,000 lives each year.[1] Highway crashes consume three percent of all United States (US) medical spending; approximately 14 percent is spent on crash victims 15 to 24 years of age.[2] Highway fatalities are the leading cause of death among the employed.[3] MVCs are responsible for more deaths to the young (age 15 to 29 years) than any other cause.[4] Among many other factors associated with fatal MVCs are young driver and male driver involvement.[5] By virtue of these three risk factors (employment, youth, gender), our nation's mostly young and predominantly male military population is at particular risk for fatal MVC. In fact, MVCs are the leading cause of death among military members.[6]

The specific aims of this population based observational study were to:

1) Quantify factors of MVCs that severely injured or killed USAF personnel.
2) Compare USAF MVC factors to those involving other populations.
3) Identify military or USAF unique intervention opportunities.

Notes

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Chapter 2

Background

Factors associated with motor vehicle crashes are well documented, and include the following often interrelated characteristics: impaired driver, vehicle speed, night and weekend occurrence, driver fatigue, young vehicle occupants, male drivers, driver inexperience and inattentiveness, and undesirable atmospheric and road conditions. In the event of a crash, many of these factors are also associated with increased injury severity and death, as are misuse or no use of occupant protection systems (e.g., safety belt, motorcycle helmet).

Alcohol impairment remains a huge contributor to fatal MVCs. In 1999, 38 percent of MVC fatalities were related to alcohol.[1] This proportion has decreased from 52 percent in 1986.[2] Miller and colleagues estimate the safety costs of drunk driving per mile to be 52 times the safety costs per mile driven sober.[3] Not only does alcohol increase crash risk by affecting judgment and psychomotor performance, it increases vulnerability to serious injury in any given MVC.[4]

Speeding, including too fast for conditions within the limit, contributed to 30 percent of 1999 fatal MVCs, claiming 12,998 lives.[5] The annual burden to society from speeding is $28 billion.[6] In such crashes, young males were more likely driving.[7] About 36 percent of fatal MVCs involve 15 to 20 year old drivers who were speeding at the time of the crash.[8]

Thirty-nine to 59 percent of truck crashes are driver fatigue or inattention related.[9] Lindsay and colleagues found dozing causal in at least 44 percent of university student MVC fatalities,

and estimated the potential incidence of dozing driver deaths in their 1981-96 study to be as high as 13.7 fatalities per 100,000 (100K) college students.[10] Nighttime driving fatigue is more associated with human circadian rhythm than the task of driving itself.[11]

When considering vehicle miles traveled, young drivers have the highest MVC risk, which is also associated with inexperience (less than a year of driving).[12] Young drivers are at greater risk for single-car, summer, weekend, and nighttime MVCs.[13] Youth (particularly young women) are less proficient at some driving skills.[14] The risk of fatal injury and at-fault crashes among young drivers increases with the presence of peer occupants,[15] and the number of peer occupants.[16] The fatal crash involvement rate of male drivers is three times that of females.[17] This is partially explained by greater on-road exposure among males.[18] When considering all occupants, male occupant fatality is twice that of women.[19] Despite these differences, MVC *injury* rates are slightly higher among women.[20] Explanations for the sex-related fatality versus injury difference include the higher male prevalence (particularly among young peers) of driving while impaired or fatigued, illicit drug use, speeding, and non-use of seat belts.[21]

Restraint use has improved over time. In 1999, safety belt use was estimated at 67 percent in the US; however, nearly 50 percent of occupants involved in fatal crashes were not restrained.[22] Among restrained fatal crash occupants, only one percent were totally ejected from their vehicle compared to 22 percent of those unrestrained. Three fourths of all ejected occupants were killed.[23] Just 13 percent of unrestrained occupants account for 42 percent of MVC costs.[24]

Motorcyclist fatalities represent six percent of MVC fatalities, and are somewhat seasonal with peaks occurring in June, July, and August.[25] Speeding and impairment are common factors among at fault motorcycle operators.[26] Left turns and failure to yield are common factors where other at fault operators injured a motorcyclist. Though excess motorcyclist speed occasionally

contributes, failure to see the motorcyclist either at all, or in time to avoid crash, are common explanations.[27] Approximately 45 percent of operators and 55 percent of passengers killed are un-helmeted at impact.[28] Young motorcyclists are particularly prone to serious injury or death. Rutter and Quine determined the role of youth itself to be a greater contributor than inexperience. The youth-associated behaviors of willingness to break laws and disregard for safe riding standards are more prevalent among younger motorcyclists.[29]

MVCs claimed 4906 pedestrian lives, or 12 percent of MVC deaths in 1999.[30] Nearly half of these events involved alcohol; 31 percent of pedestrians killed were intoxicated. In 12 percent of pedestrian-MVCs, vehicle drivers were impaired; in six percent, both driver and pedestrian were intoxicated. Street lighting, conspicuousness of the pedestrian, young and old age, male sex, and weather are also associated with pedestrian fatalities.[31] Two percent of 1999 MVC fatalities were bicyclists. Most were male (80 percent), and younger than 44 (72 percent). Bicyclist-MVC fatalities tend to be seasonal, with two-thirds occurring during May through September.[32]

Automobile minimum safety standards, crashworthiness improvements, helmet laws, seat belt laws, and fewer alcohol impaired drivers[33] explain why ten thousand fewer lives were lost in 1999 than in 1980 despite population growth.[34] Though youth remain over-represented in deaths, a gradual decline in some risk factors among 15 to 20 year old drivers has been noted. During 1988-95, the involvement rate of 15 to 17 year old drivers in fatal MVCs declined 15.5 percent, among ages 18 to 20 it declined 22 percent, and among ages older than 20 it declined 13.5 percent.[35] The proportion of unrestrained young drivers who were involved in fatal MVCs dropped from 60 percent in 1988 to 46 percent by 1995. The proportion of nighttime fatal crashes declined from 42 percent in 1988 to 35 percent in 1995. Finally, MVC fatalities associated with impaired young drivers fell from 32 percent in 1988 to 20 percent by 1995.[36]

United States Armed Forces men and women comprise a special sub-population of the US. Nearly twenty percent of all military recruits each year enter service without a driver's license; about 4500 are Air Force recruits.[37] Approximately 13 percent of the active duty force is younger than 21 years of age, 62 percent are younger than 31 years of age, and 87 percent are male. These distributions are quite different from the US general population, where about half are male, and 43 percent of 17 to 64 year old licensed drivers (age range of most military members) are at least 40 years old. The demographic traits and relative driver inexperience of military members implies fatal MVC vulnerability. The frequent travel associated with temporary duty assignments and periodic moving further increases this risk by increasing road and nighttime exposure. Published literature that quantifies and explores the MVC risk of military personnel, however, is elusive. This project begins to correct this deficiency.

Notes

[1] National Highway Traffic Safety Administration. *Traffic Safety Facts* 1999. Washington DC: National Highway Traffic Safety Administration, 1999.

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[12] Massie DL, Campbell KL, Williams AF. "Traffic accident involvement rates by driver age and gender." *Accident Analysis and Prevention.* 1995;27(1):73-87.

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Chapter 3

Materials and Methods

Data were obtained from three primary sources: The Air Force Personnel Center (AFPC), National Highway Traffic Safety Administration (NHTSA), and the Air Force Safety Center (AFSC). USAF personnel data were retrieved from AFPC, Randolph Air Force Base, Texas. Supplemental information on the cadet population was obtained from the Air Force Academy, Colorado. Personnel strength varied each of the 12-years under study. In its fullest year (1988), the USAF employed 576,455 personnel, compared to 356,487 in its lowest year (1999). Approximately 5,425,549 person-years (py) accrued during this time, 85 percent of which were contributed by males. The proportion of active duty males was lowest (78 percent) among the youngest (17 to 21) age group, and highest (92 percent) among the eldest (over 45) age groups.

NHTSA data were taken from many of their publications which are also available online at: *http://www-fars.nhtsa.dot.gov*. NHTSA compiles these data through two systems: the Fatality Analysis Reporting System (FARS), and the General Estimates System (GES). As the name implies, FARS is a reporting system for fatal MVCs occurring within the 50 states and the District of Columbia. The GES uses injury (non-fatal) and property-damage MVC data collected from 60 US locations for generalizable probability-based models. MVCs reported to FARS include US occurring military fatalities, but exclude those occurring in other countries. US MVC fatality rates presented for comparison were either licensed driver based (per Federal

Highway Administration to NHTSA), or US population based (per census estimates to NHTSA). The former were preferred, as licensed drivers more closely resemble the USAF population than does the general US population; however, such data were not available for all comparisons. The USAF source population and fatal case events under study nearly represent subsets of the US comparative population and MVC events, respectively, with the exception of USAF MVC events that occurred outside the US. Models with USAF data subtracted from US data did not differ statistically from models leaving them in, thus USAF data were left in final US models.

Two USAF case files (case events, case personnel) were prepared. Case events (N=893) were MVCs that occurred in fiscal years 1988-99 that left at least one USAF member killed or permanently disabled. These events, reported to AFSC,[1] include vehicle-pedestrian, vehicle-train, vehicle-bicycle, and motorcycle MVCs. Information on non-USAF personnel involved in case events is limited. Fatal events (N=794) were compared to permanently disabling-only events (N=99), and no differences were found. Thus in the interest of statistical power, crash factor analyses include all 893 events. Analyses of fatality, as implied, exclude non-fatal cases. Case personnel (N=950) were the airmen killed or disabled in case events.

Each MVC was reviewed in search of the following factors: date, time, single or multiple vehicle collision, assigned installation location (US, non-US), and unfavorable road or weather conditions. MVC operator factors of interest (coded yes, no, suspect, or not determined) included fatigue, impairment (particularly alcohol), inexperience, speed, and recklessness other than speeding. Characteristics of case personnel were also quantified, and include vehicle occupant status (operator, passenger, pedestrian, bicyclist), age, sex, sobriety,[2] duty status, and occupant protection compliance. Where it could be determined, the later were coded ‘yes’ for occupants who were properly restrained (non-motorcycle occupants) or who were wearing a

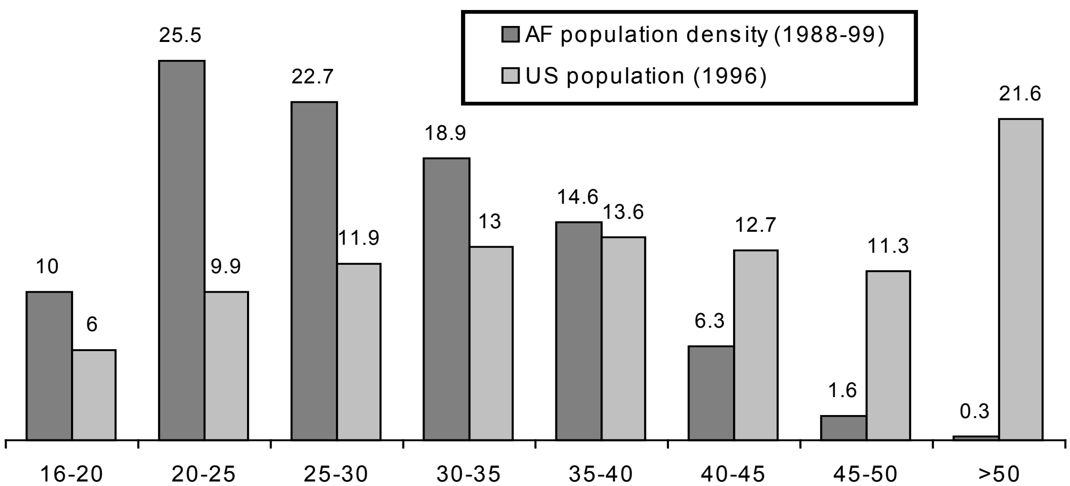
helmet (motorcyclists). The code ‘no’ was given for no use, improper use (such as shoulder harness without lap belt, unbuckled helmet), or not available (includes pickup beds). A final review was done to capture information relevant to two outcomes: 1) whether a USAF member was at least partially responsible (includes fully) for initiating the MVC event sequence (USAF responsible, non-USAF responsible, undetermined), and 2) the likelihood of avoiding crash for events in which USAF personnel were likely *not* at fault (likely avoidable, likely unavoidable, undetermined). It is important to note that the dichotomous categorization of responsibility was subjective, and that ‘USAF responsible’ did not always imply ‘self.’ Case personnel were killed or injured in vehicles driven by USAF and non-USAF drivers, who were or were not at fault. Univariate analyses were conducted on the previous factors.

Multivariate analyses were also conducted using linear and logistic regression models, as well as Risk Ratio (RR), Relative Risk (ReR), and Mantel-Haenszel Odds Ratio (OR) estimate techniques, to best isolate interactive factors of interest while reducing potentially confounding effects of other factors. Specific annual MVC factor-involvement rates (impairment, fatigue, speed, recklessness, occupant protection and inexperience) were tested for linearity (annual trend) by the Mantel Extension test. Risk estimates were calculated with 95 percent confidence, such that the probability (P) of type I error (alpha) was no greater than 0.05. All statistically significant risk estimates reported are followed by 95 percent confidence intervals. Statistical analyses were aided by SPSS version 10.0.7[3] and Epi Info 2000 version 1.0.5[4] software.

The USAF MVC occupant fatality experience was compared to the US general population. USAF demographic data were retrieved from AFPC as 12 spreadsheets (one per year) reflecting number of personnel double-stratified by sex and five-year age categories (17 to 21, 21 to 25, … 51 to 55, over 55). NHTSA supplied data in slightly different age categories, which presented a

comparison problem. Age distributions of the 12-year USAF population density are compared to 1996 US population data in Figure 1; the proportional disparity is also evident. Age-specific comparisons used the closest age category, and considered this circumstance. Day and time comparative analyses were also conducted using a case file of 1998 US fatal MVCs (N=36,377). One year was sufficient for comparison, as US MVC day and time trends are consistent.[5]

Figure 1 USAF and US Comparative Age Distributions



Age ranges displayed on x-axis accommodate both USAF and US age category windows. USAF range includes 17-20, 21-25, etc., while the US range includes 16-19, 20-24, etc.

Notes

[1] Air Force Instruction 91-204, *Safety Investigations and Reports*, 1 October 99.

[2] Regarding sobriety, a few reports noted that individuals were tested several hours post-crash. These results were converted to the crash time estimate by using the AF Security Forces alcohol interpolation formula of a 0.015 level decrease per hour.

[3] Statistical Package for the Social Sciences version 10.0.7, 1 June 2000. SPSS Inc. Headquarters, Chicago, Illinois.

[4] Epi Info 2000 version 1.0.5, 14 June 2000. Division of Surveillance and Epidemiology, Epidemiology Program Office, Centers for Disease Control and Prevention, Atlanta, Georgia.

[5] National Highway Traffic Safety Administration. Fatality Analysis Reporting System; 1988-1999. Washington, DC: US Dept of Transportation; 1988-1999.

Chapter 4

Observations and Results

During the 12-year study period, 840 USAF personnel lost their lives and an additional 110 were permanently disabled in 893 MVCs. Select event factors are in summarized in Table 1. A motorcycle was involved in 182 (20 percent) case events; these factors are also separately presented in Table 1. Characteristics of case personnel include that 849 (89 percent) were male, 372 (39 percent) were 21 to 25 years of age, 139 (15 percent) were on leave, and 186 (20 percent) were motorcyclists. These and other traits of case personnel are presented in Table 2.

Table 1 USAF Motor Vehicle Event Factors

Characteristic	All events (N=893) #	All events (N=893) %	Motorcycle events (N=182) #	Motorcycle events (N=182) %
Fiscal Year				
1988 – 1990	331	37	62	34
1991 – 1993	213	24	42	23
1994 – 1996	205	23	44	24
1997 – 1999	144	16	34	19
Vehicle factors				
Single-vehicle crash	476	53	84	46
Bicycle involved	12	1	1	<1
Pedestrian involved	34	4	-	-
Train involved	9	1	-	-
Motorcycle involved	182	20	-	-
Installation				
Continental US	695	78	142	78
Non-US	198	22	40	22
Day of week				
Weekday	512	57	103	57
Weekend	381	43	79	43
Crash event factors (suspect)				
Impairment	352	40	59	32
Fatigue	174	19	6	3
Excessive speed	350	39	87	48
Recklessness (other than speed)	65	7	18	10
Weather / road / animal hazard	128	14	22	12
Inexperience	36	4	29	16
Restraint system / helmet	303	34	35	19

Table 2 Characteristics of USAF Case Personnel

Characteristic	#	%
Involvement status		
Motorcycle operator	177	19
Other vehicle operator	507	53
Motorcycle passenger	9	<1
Other vehicle passenger	209	22
Bicyclist	12	1
Pedestrian, jogger	36	4
Age		
<21	200	21
21-25	372	39
26-30	165	17
31-35	104	11
36-40	73	8
41-45	21	2
46-50	13	1
>50	2	<1
Median age	24	
Sex[a]		
Male	849	89
Female	100	11
Rank		
Cadet	14	1
Enlisted	859	90
Officer	76	8
OSI	1	<1
Duty Status		
Leave	139	15
Temporary Duty	57	6
Permanent Change of Station	5	<1
Other		
Properly restrained in vehicle[b]	377	53
Properly helmeted motorcyclist[c]	153	82
Non-sober	306	32
Intoxicated (BAC 0.08 % or higher)	214	23

[a]The sex of one individual was not determined.
[b]Among 716 vehicle occupants
[c]Among 186 motorcyclists

Impairment

Operator impairment (including suspicion of) was a factor in 353 (40 percent) MVC events. In most (275; 78 percent), USAF responsibility[1] was a co-factor. Among case personnel, 306 of

950 (32 percent) had non-zero alcohol levels as determined by either quantitative test or by witness statement affirming alcohol consumption prior to crash (herein 'non-sober'). Among 507 non-motorcycle case operators, 235 (46 percent) were non-sober at crash; 51 of 177 (29 percent) motorcycle operators were non-sober. Among 36 case pedestrians, 15 (42 percent) were non-sober. Among case personnel quantitatively tested (by blood, urine, or breath analysis), 214 had alcohol levels equivalent to or greater than 0.08 percent. Thus, a *minimum* of 23 percent of all case personnel were intoxicated at the time of their fatal or disabling injury event. Compared to females, males were over represented nearly four-fold (ReR=3.75; 2.19, 6.41).

Impairment was associated with other MVC factors. When impairment accompanied non-motorcycle events, speeding was three times more likely to have been a co-factor (3.03; 2.21, 4.15), and no restraint was near twice as likely a co-factor (1.95; 1.43, 2.67). When impairment accompanied motorcycle events, no helmet was almost three times as likely a co-factor (2.74; 1.29, 5.82), and USAF responsibility was over twice as likely compared to events in which impairment was not a factor (2.64; 1.18, 5.95).

In 36 events, same-car multiple occupants were quantitatively tested for alcohol. In nine (25 percent), the operator's alcohol content was equal to or less than other occupants. However, in 27 (75 percent) the operator's alcohol content was greater than other passenger(s) tested. In seven of the latter (26 percent; 19 percent overall), at least one passenger in the respective vehicle had *zero* alcohol (herein 'sober'). Excluding these seven combinations, the mean blood-alcohol content (BAC) percentage difference between operator and passenger(s) was 0.07.

Speeding

In 350 (39 percent) events, speeding or traveling too fast for conditions was considered a factor. USAF responsibility was associated, such that speeding was 83 percent more likely a co-

factor in USAF responsible MVCs compared to non-USAF responsible MVCs (1.83; 1.26, 2.64). When impairment was a factor, speeding (excluding cases too fast for conditions within the speed limit)[2] was over four times as likely a co-factor (4.58; 3.22, 6.50).

Day and Time

Weekends claimed 381 (43 percent) events, and 412 personnel (43 percent). Though weekend occurrence is also common for US MVCs, USAF weekend events still were 28 percent more common than US weekend MVCs (ReR=1.28; 1.18, 1.38).[3] Saturday carried the highest risk, where USAF events were 35 percent more common than US events (ReR=1.35; 1.20, 1.52). USAF Sunday occurrence was 19 percent more common (ReR=1.19; 1.04, 1.37). In contrast, USAF events were 33 percent less common on Monday (ReR=0.75; 0.61, 0.92) and Thursday (ReR=0.75; 0.62, 0.92) compared to same-day US events. Day and time distributions of USAF events are in Table 3. Histograms comparing time of case USAF and fatal US MVCs follow in Figure 2, where event times were collapsed into three-hour increments.

Most striking was the 48-hour period between 1200 Friday and 1159 Sunday, herein called the critical period, where a total of 406 (46 percent) events occurred. Though this block of time was the most deadly for both populations, the occurrence of USAF events remained 27 percent more common than US events (ReR=1.27; 1.18, 1.36). Noon Sunday through 1159 Friday was protective, such that during this time USAF events were 18 percent less common than US events (ReR=0.85; 0.80, 0.90). These differences are related to working status.

When looking at the USAF experience, the critical period influenced other factors. During this time, impairment was 83 percent more likely a co-factor in motorcycle events (1.83; 1.35, 2.47), and over three times more likely a co-factor in non-motorcycle events (3.13; 1.64, 5.96).

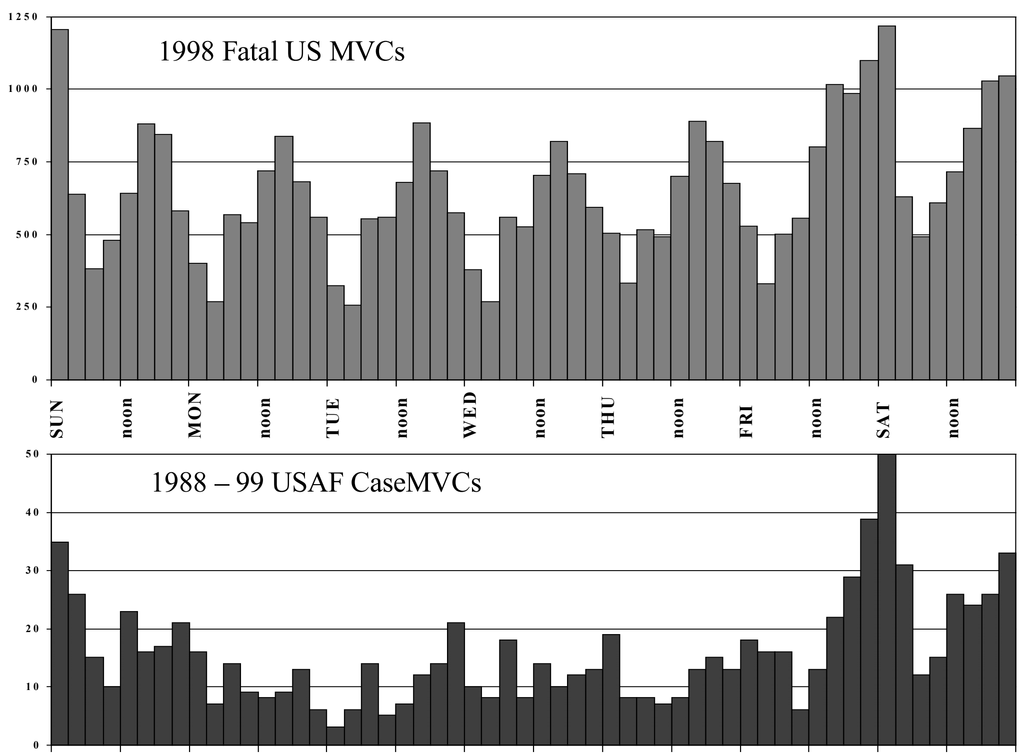
When impairment accompanied critical period MVCs, speeding was over four-fold as likely to also be a co-factor (4.58; 3.19, 6.48).

Table 3 Day and Time of USAF Case Events

	Day of Week							
Time	Sun	Mon	Tue	Wed	Thu	Fri	Sat	Total
2400-0259	35	16	3	10	19	18	50	151 (17%)
0300-0559	26	7	6	8	8	16	31	102 (11%)
0600-0859	15	14	14	18	8	16	12	97 (11%)
0900-1159	10	9	5	8	7	6	15	60 (7%)
1200-1459	23	8	7	14	8	13	26	99 (11%)
1500-1759	16	9	12	10	13	22	24	106 (12%)
1800-2059	17	13	14	12	15	29	26	126 (14%)
2100-2399	21	6	21	13	13	39	33	146 (16%)
Total	163 (18%)	82 (9%)	82 (9%)	93 (10%)	91 (10%)	159 (18%)	217 (24%)	887 (100%)

Time was unknown for 6 events.

Figure 2 Day and Time Distributions of USAF and US MVCs



Note that y-scales differ. Horizontal gridlines represent 250 US cases, and 10 USAF cases.

Fatigue

Fatigue was a factor in 174 (19 percent) crashes, only six (three percent) of which involved a motorcycle. Fatigue related events were associated with weekends and nighttime, which is evident by the proportional distributions presented in Table 4. Fatigue was 33 percent more likely a factor in MVCs occurring between 2100 and 0559 (1.33; 1.02, 1.73), and 23 percent more likely during a weekend than on weekdays (1.23; 1.03, 1.46). Fatigue was also 42 percent more likely during the critical period (1.42; 1.00, 2.00).

Table 4 Day and Time of Fatigue-Related MVCs

Time of Day	#	%		Day of Week	#	%
2400-0259	36	21		Sunday	33	19
0300-0559	38	22		Monday	14	8
0600-0859	33	19		Tuesday	10	6
0900-1159	10	6		Wednesday	16	9
1200-1459	17	10		Thursday	15	9
1500-1759	7	4		Friday	32	18
1811-2059	16	9		Saturday	54	31
2100-2359	16	9		*Total*	*174*	*100*

Occupant Age and Sex

Young age was strongly associated with case MVCs. When compared to their respective population densities, airmen under 26 years of age were almost three-fold over-represented (ReR=2.77; 2.44, 3.16); the youngest (less than 21 years) were two and a half times over-represented (ReR=2.44; 2.09, 2.85). Age- and sex-stratified occupant fatality rates are found in Table 5. Among airmen, overall male occupant fatality was 60 percent higher than among females (ReR=1.60; 1.28, 2.00). This did not vary significantly by age group (P=0.2), and was consistent over time (P=0.3), despite declining fatality incidence over time. By comparison, the

1996 US population based male occupant fatality rate for ages 16 to 64 was over two times greater for males (ReR=2.36; 2.30, 2.42); these data are also in Table 5 (note age category differences).[4] The crude overall USAF occupant fatality rate was 15.5 per 100K py; however, stratum-specific rates are more meaningful as age and sex influence fatality. Rate fluctuations between strata make this evident (Table 5). For comparison purposes only, USAF occupant fatality rates were adjusted to fit the approximate age and sex distributions of the US population and are also presented. In essence, were the USAF population proportioned similar to the US, the USAF occupant fatality rate estimate would be 12.3 fatalities per 100K py, compared to a US rate of 18.5 per 100K population. USAF occupant fatality is significantly lower by all indicators. This difference is largely due to lower USAF male fatality, particularly among males 21 years and older. Overall, USAF male occupant fatality was half the US male rate (Mantel-Haenszel age-weighted OR=0.51; 0.55, 0.59); USAF female occupant fatality was 67 percent of the US female rate (Mantel-Haenszel age-weighted OR=0.60; 0.75, 0.93).

Annual USAF occupant fatality rates stratified by sex are presented in Table 6. These are also adjusted for sex distribution disparity, and compared to same year US licensed driver based MVC fatality rates. Age-weighted calculations were attempted, however, the required US age elements were unavailable. When compared to the US population, annual USAF MVC occupant fatality was consistently lower each year; it was remarkably low in 1998.

Table 5 Occupant Fatality Comparison

USAF 1988 – 1999 (per 100K py)					US 1996 (per 100K population)			
Age	Overall	Males	Females	Sex-adjusted	Age	Overall	Males	Females
<21	33.8	38.6	17.0	27.6	16-20	31.4	41.88	20.23
21-25	23.6	26.3	12.6	19.4	21-24	29.39	43.58	14.49
26-30	11.7	13.4	9.7	11.6	25-34	18.55	27.12	10.57
31-35	8.7	9.4	3.7	5.6				
36-40	7.5	8.1	3.2	5.7	35-44	15.01	20.96	9.13
41-45	5.9	5.6	8.7	7.1				
46-50	13.5	11.0	42.0	26.5	45-54	13.48	18.67	8.51
>50	11.7	12.8	-	-	55-64	14.13	18.87	9.81
Overall	15.5	16.4	10.3	13.4	Overall[a]	18.48	26.03	11.03
Age-adjusted		13.8	10.7	-	- Reference -			
Age- and Sex-adjusted				12.3				

[a]The overall US occupant fatality rate includes ages 16-64 only.

Table 6 Annual Occupant Fatality 1988-1999

	USAF 1988 - 1999				US 1996	Risk Ratio USAF to US
Year	Male	Female	Overall	Sex-Adjusted	Overall	
1988	25.1	16.1	23.9	20.6	28.91	0.71 (0.62-0.82)
1989	15.8	11.7	15.2	13.7	27.53	0.50 (0.45-0.63)
1990	17.3	13.5	16.8	15.4	26.70	0.58 (0.49-0.68)
1991	17.6	12.4	16.8	15.0	24.56	0.61 (0.52-0.72)
1992	13.4	5.8	12.3	9.6	22.67	0.42 (0.35-0.52)
1993	13.5	4.5	12.1	9.0	23.19	0.39 (0.31-0.48)
1994	18.6	12.1	17.6	15.3	23.21	0.66 (0.56-0.78)
1995	17.8	10.9	16.7	14.4	23.68	0.61 (0.51-0.72)
1996	12.6	9.3	12.1	11.0	23.43	0.47 (0.39-0.57)
1997	17.3	15.2	17.0	16.3	23.00	0.71 (0.60-0.83)
1998	10.6	1.5	9.0	6.1	22.44	0.27 (0.21-0.35)
1999	12.0	9.1	11.5	10.6	-	-
Average[a]	16.4	10.3	15.5	13.4	24.48	0.55 (0.46-0.65)

[a]USAF average rates were calculated as 12-year incidence densities. Because US annual rates were based on census estimates, the average (overall) US rate was calculated as the mean of annual rates.

Operator fatality resembled occupant fatality. Age- and sex-stratified USAF operator fatality rates are found in Table 7, where they are also compared to US licensed driver based rates; note one year age group difference. Among airmen, male operator fatality was almost twice that of females (ReR=1.95; 1.47, 2.60). Within the US, male operator fatality among ages 16 to 64 was three fold higher (ReR=3.00; 2.91. 3.10). When comparing the two populations, USAF female operator fatality was 44 percent lower than among US females (Mantel-Haenszel age-weighted OR=0.69; 0.52, 0.92); age-stratum specific differences were not statistically stable due to low numbers within strata. The difference between males of similar age categories was strong and consistent, where USAF male operator fatality was between 64 to 89 percent lower [(Overall Male RR=0.61; 0.56, 0.66), (Mantel-Haenszel age-weighted OR=0.53; 0.49, 0.58)].

Table 7 Operator Fatality Comparison

AF 1988-1999 (per 100K py)				US 1996 (per 100K licensed drivers)				Male Fatality Risk Ratio
Age	Male	Fe	All	Age	Male	Fe	All	USAF to US
17-20	25.9	7.7	22.1	16-19	36.1	14.9	25.9	0.65 (0.53-0.78)
21-25	18.8	7.2	16.6	20-24	35.8	9.5	23.0	0.53 (0.46-0.60)
26-30	10.4	6.4	8.9	25-29	22.7	6.9	15.0	0.46 (0.38-0.56)
31-35	7.8	3.7	7.2	30-34	19.6	6.4	13.1	0.40 (0.31-0.50)
36-40	6.4	2.1	5.9	35-39	16.6	5.8	11.2	0.39 (0.29-0.52)
41-45	3.9	8.7	4.4	40-44	14.7	5.0	9.8	0.27 (0.15-0.47)
46-50	8.6	14.0	9.0	45-49	13.4	4.5	8.9	0.64 (0.31-1.35)
>50	6.4	-	-	50-64	13.0	5.3	8.9	0.49 (0.07-3.50)
Overall USAF male to US male Risk Ratio								**0.61 (0.56-0.66)**

Occupant Protection

A total of 292 of 716 (41 percent) case airmen were not restrained; use was not determined in 47 personnel. Youth were hugely over represented. Twenty-six percent were less than 21 years (compared to 10 percent population density at risk), and 43 percent were 21 to 25 years old (compared to 26 percent population density). Airmen under 26 years of age were over five and a half times more likely to have been an unrestrained MVC case occupant compared to their older associates (ReR=5.61; 4.44, 7.08). Fifty-two percent of case males were restrained versus 74 percent of case females. Males were twice as likely as females to have been an unrestrained case occupant (ReR=2.09; 1.37, 3.21). Non-sobriety and no restraint were firmly related; 73 percent of sober occupants were restrained versus 34 percent of those non-sober. The likelihood of no restraint was near four-fold higher among the non-sober (3.72; 2.77, 5.02). Gender modified this risk, such that among non-sober males, no restraint was over four-fold higher (4.19, 2.82, 6.20).

Regarding crash factors, no restraint was 58 percent more likely a co-factor when speeding accompanied (1.58; 1.15, 2.15); no restraint was near twice as likely when excluding speeding cases that were within the limit, but too fast for conditions (1.95; 1.40, 2.72). As previously reported,[5] no restraint was 95 percent more likely when impairment was a co-factor. If the crash occurred during the critical period, the likelihood of no restraint was similar (1.94; 1.42, 2.66).

Motorcycles

USAF motorcyclists comprised 161 of 840 (19 percent) fatalities, representing a much greater proportion than US MVC fatalities (six percent). The 12-year USAF motorcyclist fatality rate was 2.97 per 100K py, compared to an estimated US rate of 1.47 per 100K people; however, the number of motorcyclists within each population (hence exposure) was unknown. Though age and sex biases and unknown exposure make it inappropriate to compare, the large disparity

in the latter two 'soft' indicators suggests that the risk of motorcycle MVC fatality to airmen is significant. Sixty-two percent of case motorcyclists were under age 26, compared to 36 percent of the USAF population at risk. Airmen under age 26 were three times over represented for motorcyclist fatality compared to those 26 years of age and older (ReR=2.94; 2.18, 3.95).

The most common motorcycle MVC factors were excessive speed (48 percent), impairment (32 percent), unseen motorcycle (27 percent), no helmet (19 percent), and inexperience (16 percent). Unseen motorcycle events involved other drivers who did not see the motorcycle in time to successfully avoid collision. Where responsibility could be determined in the latter case events (N=45), non-USAF people were at fault in 34 (76 percent). Thirty of 186 (nine percent) case motorcyclists were not helmeted at impact. USAF responsibility was a factor in most events (29 of 35; 83 percent) where no helmet was also a co-factor. During the critical period when impairment accompanied, no helmet was almost three-fold more likely a co-factor (2.77; 1.26, 6.07). These interactions, and other previously mentioned (includes non-motorcycle) co-factor interactions among case events and case personnel are presented together in Table 8.

Table 8 Interactions of Motor Vehicle Crash Factors

MVC Factor Interactions	Motorcycle Event		Non-Motorcycle Event	
	OR[a]	95% CI	OR	95% CI
Impairment a Factor (N = 353)				
Speeding	-	-	3.03	2.21-4.15
Speeding with exclusions[b]	-	-	4.58	3.22-6.50
Occupant protection	2.74	1.29-5.82	1.95	1.43-2.66
Critical period	3.13	1.64-5.96	1.83	1.35-2.47
AF shares responsibility	2.65	1.18-5.95	1.41	0.99-1.99
Speeding a Factor (N = 350)				
Occupant protection[c]	-	-	1.58	1.15-2.15
AF shares responsibility	15.0	5.56-40.5	1.83	1.26-2.64
Speeding a Factor, too fast for conditions excluded (N = 285)				
Occupant protection	-	-	1.95	1.40-2.72
Events Occurring During Critical Period (N = 406)				
Fatigue	-	-	1.42	1.00-2.00

Case Personnel Factor Interactions	All Events	
	Risk Estimate	95% CI
Male to female risk of non-sobriety in a case MVC	ReR = 3.75	2.19- 6.41
Male to female risk of no restraint in a case MVC	ReR = 2.09	1.37-3.21
Likelihood of no restraint (vehicle) when non-sober	OR = 3.72	2.77-5.02
Among males only, no restraint when non-sober	OR = 4.19	2.82-6.20
Age <26 to 26+ yrs risk of no restraint in a case MVC	ReR = 5.61	4.44-7.08

[a]Risk estimates expressed as Odds Ratios (OR).
[b]Excluding case events where speeding was within the limit, but too fast for conditions
[c]Occupant protection implies no or improper use of helmet for motorcycle events, and no or improper use of restraint systems for non-motorcycle events.

Annual Trends

Within the USAF population, occupant fatality, male occupant fatality, and male operator fatality significantly declined over time (all $P<0.04$). Additionally, involvement of the following specific MVC factors significantly declined over time: impairment, critical period, speeding, occupant protection, and USAF member responsibility (all $P<0.04$). These and other factors tested for linearity (annual trend) are presented in Table 9. This table also presents the average annual decline among those that were statistically significant.

Table 9 Fiscal Year Trends of Specific MVC Factors

	Year Group					Linear Association of Annual Rates	
Factor of Interest	Overall	88-90	91-93	94-96	97-99	P-value[a]	Annual Rate Reduction
Fatal Events (N=840)							
Occupant Fatality	15.5	18.7	13.9	15.5	12.5	0.037	0.57 (0.73-1.07)
Gender specific							
Male	16.4	19.5	14.9	16.5	13.4	0.035	0.59 (0.08-1.09)
Female	10.3	13.7	7.7	10.8	8.6	0.154	-
Male Operator	12.0	14.9	10.4	12.0	9.7	0.034	0.77 (0.12-1.43)
Age specific							
<21	33.8	40.1	32.6	33.0	26.9	0.136	-
21-25	23.6	27.6	20.9	26.8	17.3	0.146	-
26-30	11.7	12.3	10.6	12.4	11.3	0.818	-
31-35	8.7	10.8	8.3	8.6	6.6	0.125	-
36-40	7.5	10.8	5.3	5.0	8.9	0.543	-
>40	8.1	9.4	6.7	4.0	7.2	0.186	-
All Events (N=893)							
Day/Time Period							
1200Fri-1159Sun	7.48	9.15	7.16	7.81	5.00	0.002	1.56 (0.74-2.37)
1200Sun-1159Fri	8.92	10.46	7.79	8.88	8.08	0.108	-
Factors specific							
Impaired	6.5	9.2	6.1	5.7	3.8	0.004	1.29 (0.79-1.79)
Fatigue	3.2	4.7	2.2	2.5	3.0	0.097	-
Speed	6.5	8.1	5.5	6.7	4.9	0.033	1.17 (0.19-2.15)
Occupant protect.	5.6	8.0	4.3	5.5	3.5	0.024	1.04 (0.26-1.11)
AF responsibility							
AF member	11.9	15.0	10.3	12.2	9.0	0.025	0.63 (0.14-1.11)
Not AF member	4.2	4.3	4.3	4.5	3.5	0.230	-

[a] Values represent the significance scores (alpha probability) for the Mantel Extension test.

Notes

[1] As described in the Materials and Methods section.

[2] 'Speeding' cases within the limit but too fast for conditions were excluded to more target deliberate, rather than less intentional speeding

[3] For comparative day and time analyses, US events were the 1998 US fatal MVCs (reported to NHTSA through FARS) as described in the Materials and Methods section.

[4] For comparative fatality analyses, US MVC fatalities were the 1996 US fatalities (reported to NHTSA through FARS) described previously in the Materials and Methods section.

[5] As previously reported under the Impairment section.

Chapter 4

Discussion

A finding to be hailed in this USAF population based study is that MVC fatality was significantly low. Risks and intervention opportunities very similar to those reported in other MVC studies, however, were identified. These include the usual suspects of sobriety, speeding, occupant protection misuse, nighttime and weekend driving, and some aspects of motorcycle riding, particularly among the segment of society that has proven to be the most difficult to reach. Literature attempting to explain the persistence of these risks in clusters of youth is briefly discussed. Much of the success in reducing fatal MVCs is owed to regulatory interventions and alcohol de-glamorization. Based on risks identified, three current public health initiatives show great promise for further reducing MVC threat to military personnel. These are lower BAC limits, graduated driver licensing (GDL), and nighttime driving curfew. In closing, select intervention opportunities not specifically addressed by these initiatives are also presented.

Positive Findings

When using the 1996 population of similarly aged US licensed drivers as a reference, the USAF lost about 600 fewer lives than expected in 12 years. By extrapolation, the lives spared were 576 men and 26 women; 256 were less than 26 years, 230 were between 26 to 35 years, and 114 were older than 35. If ages 72 (male) and 75 (female) were their life expectancies, close to

20,000 potential years of life were saved. Unquestionably the higher prevalence of safety belt use among airmen explains much of this. Though not quantified in this study, the healthy worker effect and military service itself also contribute to comparatively low occupant fatality.

Restraint systems greatly enhance survivability in the event of MVC. Restraint use has been required of military members for over 12 years. Forty-nine states (except New Hampshire) and the District of Columbia have safety belt laws.[1] Compliance is greater among airmen, where about 95 percent[2] use seat belts compared to 67 percent of their parent US population.[3] NHTSA estimates seat belts saved 11,197 lives in 1999, and an additional 9553 could have been saved were they buckled.[4] Some of those spared were airmen. Women are more compliant than men regarding wear of safety belts,[5] which partially explains lower occupant fatality among USAF women. Less driving exposure and less risk taking behavior explains the balance.[6]

The favorable health status and reduced mortality among workers compared to the general population is called the healthy worker effect (HWE).[7] This advantage results from selection of relatively healthy individuals for hire, and lifestyle changes that accompany employment.[8] By selection and retention criteria, US military personnel (GIs) are in better health, better physical condition, and more sober (regarding alcohol and illicit drug use) than not only their parent population, but also the working US sub-population. This creates a 'healthy GI' effect that likely dwarfs the HWE, such that GIs are not only healthy enough to employ, they are in addition physically and mentally fit enough to be selected and retained for military duty. Retention is a virtual survival of the fittest to serve. It is quite plausible that the very characteristics that enhance military selection and retention overlap the very characteristics that reduce severe MVC injury risk. Would it be fair to assume that the prevalence of chronically impaired drivers is

greater in the non-military versus military US population? Indeed, chronic alcohol abuse is not compatible with retention in the military, however is associated with increased MVC risk.

That aside, it is completely unreasonable to assume that individuals potentially prone to risk taking are methodically, eventually weeded out. It is most plausible that the disciplined, regimented, command-organized military structure reduces this tendency in many who are prone before it is ever expressed. If the basis of 'correctional facilities' is such structure, can maturing and developing professionally in that kind of environment prior to being identified as a risk taker, or even a societal deviant, reduce proneness? It only seems highly likely.

An important and lesser-known component of military discipline and health is the safety community. Safety personnel investigate injury events that cause a worker to lose at least one day of work subsequent to their injury.[9] The investigation process, subsequent awareness, and the appropriate accountability and responsibility consequences, certainly promote health and reduce risk taking behavior. Regarding MVCs, this safety follow-through process likely saved many lives, including some of the aforementioned 600 anonymous airmen.

Positive findings also include the statistically significant annual declines in overall occupant fatality, male occupant fatality, and the following co-factors: impairment, speeding, critical period, occupant protection, and USAF responsibility. Some of the reduction reflects secular trend, as US occupant fatality similarly declined. Most is credited to airmen however, as USAF responsibility declined significantly while non-USAF responsibility did not, though latter events were a minority. Importantly, USAF responsibility was not over represented; most MVCs are single car events, and as such most carry inherent fault.[10] The non-USAF responsible occupant fatality rate (12-year incidence density) was statistically stable (P=0.23; Table 9) at 4.20 per 100K py; the annual incidence was lowest (2.81) in 1999, and highest (5.53) in 1992. Also

remarkable is that the *difference* in occupant fatality between US and USAF populations (USAF lower) was statistically consistent, despite decreasing annual rates by each population.

Intervention Opportunities

Risk and Youth

Danger and delight grow on one stalk.

—English proverb

The scientific literature is rife with identified MVC risks, many of which are commonly attributed to inexperience and lifestyle factors that predispose a proportion of the young (and male) in particular to heightened risk levels.[11] In Johah's fine review of sensation seeking and risky driving, he concludes that sensation seeking is highly correlated with non-sober driving and risky driving, that there is less perceived risk among sensation seekers, and that a genetic predilection explains at least some sensation seeking (thus risky driving).[12] Young risk-takers typically grow out of such behavior in time, however are consistently replaced with more who are coming of age. This dynamic population at risk – representing 15 percent of the US population and 36 percent of the military population – has proven most difficult to reach through traditional means. Scientific literature dedicated to successfully lowering (and maintaining) the willful risk taking propensity of youth in particular is scant. Regulatory interventions are the exception, some of which are hugely successful. Among these are laws governing safety belt use, speed limits, helmet use, tougher DUI consequences, raised minimum age drinking, lower BAC limits, GDL, and curfews.[13] Given the findings of this study and military culture, the latter three interventions show promise of further reducing MVC fatality among military personnel.

Lower BAC Limit

If you drink, don't drive. Don't even putt.

—Dean Martin

Lowering BAC limits universally to no higher than 0.08 percent (from 0.10 percent) is a national public health initiative. Though an improvement, it is not low enough. Scientific literature suggests a 0.05 percent minimum to be much more beneficial, and as such is supported by the American Medical Association (AMA).[14] Sun and colleagues recommend a 0.05 percent limit for motorcyclists because of the additional coordination required for operating a two versus four–wheeled vehicle.[15] Medical and comprehensive costs per MVC victim are said to increase eight-fold among drivers with BAC 0.01 to 0.079 percent compared to sober drivers.[16] The mind-altering effects of alcohol and its exacerbated effect on youth are well known. Less known are the latent effects, including sleepiness, of even small amounts. Taylor and colleagues found among young pilots that a maximum BAC of 0.08 percent caused more communication errors during *and* after eight-hour recovery.[17] Corfitsen had similar findings when he compared sober and impaired (BAC 0.08 to 0.3 percent) 18 to 30 year old drivers; visual mean reaction times were markedly slower among the impaired. Further, tiredness was greater among the impaired, particularly at nighttime (2400 to 0600).[18] Arnedt and colleagues discovered sleepiness rose with increasing BAC 30 minutes to three hours after peaks of 0.05 percent and 0.08 percent, even when compared to un-rested sober subjects. Poorer lane-keeping performance, fixed-foot speed, and off-road events increased with increasing BAC (to 0.08 percent peak) of non-sober drivers, compared to rested sober drivers. Compared to un-rested sober drivers, the latter two

undesirable driving traits were exacerbated in non-sober drivers, even after three hours.[19] Excepting Corfitsen's study, note that the highest peak BAC discussed above was 0.08 percent.

This USAF study found no less than 23 percent of case personnel to be intoxicated (BAC at least 0.08 percent) at MVC impact. Also, 47 percent of USAF operators were non-sober at impact, at least 40 percent of case MVC events involved alcohol, and 78 percent of case events carried USAF member responsibility. Recall also that among a cluster of alcohol-tested same-vehicle occupants, a more impaired individual was driving 75 percent of the time. This is not an isolated finding. When studying crash victims admitted to a trauma center, Soderstrom and colleagues discovered that alcohol levels of operators were greater than a same-vehicle passenger in a majority (68 percent) of cases. Among occupant pairs, if only one was sober, it was not the operator 58 percent of the time. Among all multiple occupants, the highest BAC individual was driving 67 percent of the time.[20] Additional characteristics of USAF case personnel are that among 203 who were less than 21 years of age, 63 (31 percent) were non-sober; 42 of the latter (42 of 63; 21 percent of total) were operators. The latter numbers are particularly disturbing considering the USAF legal drinking age was raised to 21 by 1988. Currently USAF regulations regarding BAC enforce civil law, thus BAC limits are effectively state-determined. With a high concentration of at-risk youth in the military, a universal BAC limit of 0.05 percent, which follows the AMA recommendation and is sensitive to motorcyclists, is a very sound concept, and therefore is recommended. The undesirable effects of drinking and driving, including greater risk taking, less chance of restraint use, latent cognition effects, and fatigue – even after recovery from small amounts – make this limit logical and beneficial. Zero tolerance through age 25, however, is not unreasonable and is also worthy of consideration. De-glamorization of alcohol consumption must also continue. A reduction in sports, leisure, and recreational activity related

injuries would likely be an added benefit, as a large proportion of these are also alcohol related.[21]

Graduated Driver Licensing

> *Good judgment comes from experience, and experience – well, that comes from poor judgment.*
>
> —Anonymous

The US GDL movement is relatively new, yet already successful. It is a system designed to help novice drivers learn the complexities of driving behavior in stages while reducing crash risk by its design, which addresses high risk situations, inexperience, and impulsiveness.[22] In their meta-analysis of GDL effectiveness, Foss and Evenson report a sustained seven to eight percent reduction in teenage driver crash injuries in New Zealand from GDL.[23] The standard US model considers three stages from Learner, Intermediate to Full. Learners must be supervised when driving by a parent, guardian, or other licensed driver aged 21 or older. The Learner may graduate to Intermediate if and when his driving record is conviction-free for six consecutive months. Intermediate drivers still must be supervised between the hours of 2200 and 0500. All occupants of vehicles driven by Learners and Intermediates must use safety belts. Intermediates may graduate to Full following six consecutive months of a conviction-free driving record. Many modifications of this model exist in the US, and in other countries.

Sweden's model is such that full licensing age is 18 years. Prior to 1993, a learner's permit equivalent was allowed from age 17.5 years. This allowed six months of driving practice, a period of time similar to the pre-GDL initiative in the US. In 1993, however, Sweden allowed learner's permits from ages 16 to 18, effectively increasing the potential for supervised driving practice from six months to two years. Gregersen and colleagues examined the impact of the 1993 reform on MVCs in Sweden.[24] Between 45 and 50 percent of the potentially age-affected

took advantage of the reform in the six years studied. Overall, novice accident rates declined 15 percent. Specifically, the rate among the cohort of 16 to 17.5 year olds who took advantage of this extra time declined by approximately 40 percent; the rate did not decline among those who did not partake. Results were similar for three annual cohorts of novice drivers who were followed two years after full licensure, which argues against an initiation bias.

A system that gives novice drivers more supervised practice time and reduces or removes them from higher risk situations makes tremendous sense for the military young. Among case airmen, 20 percent of car operators and 18 percent of motorcycle operators were less than 21 years old; just 10 percent of the population at risk was younger than 21. Inexperience was linked to 16 percent of motorcycle MVCs. At least 13 events involved unlicensed operators, several of who borrowed a friend's motorcycle. These findings are not unique. Fifteen to 20 percent of killed US motorcycle drivers were operating with invalid licenses at the time of their death.[25] Reeder and colleagues described the early experiences of a birth cohort of 17 to 18 year old New Zealand motorcyclists. Fifty-four percent had ridden less than twice per month, only 36 percent were licensed, and 72 percent usually borrowed motorcycles. Their recommendations were raising motorcycle licensure age, prohibiting motorcycle sale and lending to unlicensed riders, more stringent enforcement of license regulations, and tougher penalties for GDL breach.

The potential benefits of a GDL system are obvious for at least the 16,000 annual unlicensed military recruits. Potential costs are enforcement, cumbersome logistics, limited mobility, and personal defiance. However, implementation of tailored situation- or location-specific programs which capture this essence of risk reduction is recommended, particularly where youth are concentrated (training installations, technical schools), where MVC risk is high, and in any situation where potential benefits outweigh costs. Recommended also is a specifically tailored

motorcyclist GDL system that considers Reeder's highly relevant recommendations (above), and licensure only after successful completion of an approved motorcycle safety course.

Night Driving Curfew

Fatigue is the best pillow.

—Hindu proverb

Night driving curfews are often components of GDL systems, however are separately discussed because of their isolated superior benefit. The concept is to restrict nighttime driving by novices thus reducing young driver crashes. In their review on this subject, Williams and Preusser conclude that 40 percent of teenage fatal crashes occur from 2100 to 0600 while just 15 percent of their miles are driven at this time.[26] Curfews are strongly endorsed by parents of teenagers, who also favor earlier starting times than exist in most curfew jurisdictions. Foss and Evenson laud the striking performance of the curfew element that lowered crash injury and fatality rates by 23 to 35 percent in four GDL systems they reviewed.[27] Curfews beginning prior to midnight appear more effective. Miller and colleagues posit a cost-benefit ratio of four to eight for novice driver curfews that restrict driving after 2300.[28] Fully 45 percent of USAF case MVCs occurred from 2100 to 0559; 29 percent occurred from 2400 to 0559. This proportion is more significant than it appears, as the population exposed (in vehicles) is small during these hours. This speaks to the heightened and correlated risks of nighttime road travel. USAF case event time-of-crash data were not linked to case personnel, thus analyses of operator age and MVC time are absent. There is no reason to believe, however, that the USAF experience differed from what is described in literature regarding youth and nighttime driving. Most (72 percent) case airmen were operators; 20 percent were younger than 21, and 36 percent were 21 to 35 years of age. Age of operator aside, the obvious risk of nighttime driving supports the

concept of an encouraged curfew that restricts non-essential driving from 2200 to 0500; 37 percent of USAF case events occurred during this time.

Fatigue is an added, most unintentional nighttime travel risk that further amplifies the sensibility of curfew. Fatigue related MVCs tend to be lethal by their uncontrolled, violent nature. Characteristics include speeding (fixed foot), driving off the road, and head-on collisions. The most conscientious, sober, non-speeding, properly restrained drivers who successfully avoid other hazardous drivers at night still remain at great risk for MVC because of sleepiness, particularly from 2400 to 0500;[29] peak vulnerability by circadian rhythm occurs about 0300.[30] Indeed, to drive at night is to sit somewhat comfortably in darkness, attempting to defy nature's powerful instinct to prepare for and achieve sleep. Reaction times are shown to be slower among un-rested drivers between the hours of 2400 and 0600.[31] Pack and colleagues examined MVCs in which sober drivers had fallen asleep. Beside the predictable peak between 2400 and 0600, they identified a 'siesta time' peak at 1500. Fatigue co-factors were higher speeds (62 percent) and young drivers (55 percent under age 26); peak driver age was 20 years.[32] Egregiously, fatigue is often unrecognized, not valued, or frankly denied. In simulation studies, Reyner and Horne found that drivers tended to recall sleepiness post-crash, yet their pre-crash actions were fighting sleep and persisting to drive. Some subjects failed to appreciate that extreme sleepiness raises the likelihood of actually falling asleep – even while driving.[33]

Some military installations have home curfew policies for personnel under age 18. Long distance and nighttime travel may be subject to commander approval. Local policies excepted, the USAF is without universal policies for under-age (18 years) home curfew, and long distance or late hour travel. The findings of this study support the value of such policy. Many (21 percent) case personnel were traveling away from home at the time of their ill-fated MVC. A

minimum of 11 more events involved airmen driving to or from off-duty employment (second jobs); all occurred at night. The true number of case events with this particular circumstance is likely much greater, as reporting driver intent is incidental (as well as subjective). Several MVC case reports did note that either commander guidance for driving restrictions was ignored, or that the commander-approved travel plan was breached.

Based on the many risks of nighttime travel, a driving curfew for at least novice military drivers is recommended. Appropriately defining 'novice' presents a challenge, as the number of months licensed and driver age are not perfect surrogates for experience-based skill. Criteria should be sensitive enough to protect the truly inexperienced or unskilled driver who has been licensed or learning for over six months. The nighttime risk to all drivers – and their passengers – is also too important to ignore. Thus, a flexible nighttime driving curfew-like initiative that sensibly restricts non-essential travel regardless of age should also be considered.

Other Opportunities

Several improvement opportunities not specifically addressed by the latter three regulatory initiatives are worthy of discussion. These involve the following risks: safety belt compliance, unseen motorcyclist, motorcycle helmet compliance, defensive driving, animal hazards, and pedestrians and bicyclists on roadways. Heightened awareness of these risks, and the pursuit of intervention opportunities to minimize them, are recommended.

Superior safety belt behavior by USAF personnel saved lives. Unfortunately however, at least 292 case airmen were not restrained at impact. An unknown proportion of them could have been saved by restraint use. At least 160 case individuals were ejected from their vehicles; few survived. Among those in which restraint use was determined, just nine percent were properly restrained. Fortunately restraint use increased over time, and is reflected in this study. Among

determinable cases, 50 airmen were not restrained at impact in 1988 (highest annual count) compared to just nine in 1998 (lowest). Safety belt use dissenters probably include sensation seekers, individuals who do not perceive risk, and blatant risk takers. As such they will continue to be difficult to reach. Safety belt use is often the only reason crash victims survive, thus much work is needed to achieve consistent 100 percent use. Traveling in or on vehicles lacking a functional restraint system, including the beds of pickup trucks, is risky and thus discouraged.

Motorcycle riding is inherently risky. Per vehicle mile traveled, a motorcyclist is 16 times more likely to die in a MVC than a standard car occupant.[34] Two soft indicators suggest that USAF motorcyclists were at greater fatal MVC risk than their parent population. Thus choosing to be a motorcyclist should first require a risk assessment and cost benefit approach. That aside, the unseen motorcyclist is a problem. Turning in front of and failing to yield to motorcyclists is common; it ranked third among motorcycle MVC factors in this study. Forty-seven unseen motorcyclists were killed and seven more were permanently disabled in 12 years. Considering the relatively small number of motorcyclists, and an even smaller proportion of vehicle miles traveled, losing four to five airmen each year to this problem is stirring.

Though helmet use among USAF motorcyclists is likely high, it remains short of 100 percent. Just 15 percent of USAF motorcyclists were un-helmeted at impact compared to 50 percent of US motorcyclists. In the last four years only five of 47 case motorcyclists were un-helmeted. The helmet is often the only reason motorcyclists survive a crash, thus 100 percent use must be achieved. Other protective devices (gloves, boots, etc.) are also highly encouraged.

Defensive driving is a critical traffic safety concept, though continued population growth and traffic congestion may hinder crash avoidance. Among non-USAF at fault crashes (N=225), fewer than 17 percent appeared avoidable for the following reasons: 1) the needed reaction time

was too short, 2) evasive maneuvers mirrored the approaching vehicle, 3) driver was asleep, and 4) evasive maneuvers would have caused a different crash into another fixed object or vehicle.

Fourteen MVCs involved animals in roadways. In three, large animals (deer, horses) were hit; two involved motorcyclists. More telling is that in a greater portion (10 of 14; 71 percent), swerving to miss *small* animals (snake, rabbit, dog) caused much more damage than hitting them would have. Unnecessary evasive maneuvers caused head on collisions and rollover crashes. The human (driver) tendency for animal-avoidance is strong and reflexive, however the benefit of attempting to override this tendency, particularly in small animal hazard situations, is evident.

Pedestrians, joggers, and bicyclists sharing roads with vehicles make danger, more so at nighttime, and much more so when alcohol is involved. More than half of pedestrian MVCs involved alcohol; 42 percent of case pedestrians were non-sober. Sober and non-sober drivers also broke lane-keeping, which caused pedestrian and bicyclist collisions. The message to not drink and drive is clear, however choosing to walk impaired rather than riding with a sober driver is obviously also unwise. The same interventions that protect impaired individuals from driving must be sensitive enough to also consider and protect those who may walk home instead.

Limitations

The two most important limitations of this study are report bias, and that age-specific US population comparisons used similar rather than exact age ranges. Fortunately, all identified risks are not only plausible, they follow what has been reported in other MVC studies. Risk inferences were cautiously made with these considerations, and are appropriate. Comparative analyses (US and USAF) are also subject to HWE, age, and gender biases. The HWE, and its

exaggerated consequence, the healthy GI effect, were previously addressed. Adjustments for age and sex differences were adequate considering the age category limitation.

Though case event reports included subjective information, report bias was likely minimal and harmless for two reasons. First, the meticulous civil and military investigation process for severe and fatal injuries minimizes subjectivity. Second, the high number of sources minimized the potential influence of any single report source. Several different investigators were assigned to over one hundred USAF installations during the study period. This combination makes potential data misclassification non-differential, and thus harmless. Similarly, keystroke or data entry error for computerized report data fields was presumed to be minimal because of the scrutiny severe injury and fatal events garner; however, where data entry error may exist, it is presumed to have happened at random, thus also non-differential, and likely harmless.

The potential bias created by the one-year difference between USAF and US age categories, ironically, was probably negated by USAF's disparate age distribution. Excepting the youngest age category, more 'younger' than 'older' filled each five-year window (e.g., more 21, 22 than 24, 25 in the age 21 to 25 group, etc.). Because the younger within each window carried more risk, entire categories were unfairly weighted toward the higher risk of the younger within. By comparison, within each US population five-year window, age was evenly distributed. As such, their reported age-category-specific risks were not unfairly weighted by the younger within. Thus, sliding the US five-year window 'left' one year (younger) likely controlled this bias.

The reported MVC fatality risk differences between the USAF and US populations are probably underestimated for two reasons. First, the disparate USAF age distribution within five-year windows overestimated the risk of each age category, with the probable exception of the age 17-21 year group, as just discussed. Second, the 12-year USAF experience was compared to a

relatively recent single year (1996) US experience. Over time, occupant fatality declined in both populations, therefore unfairly weighting the overall USAF experience with several years of higher occupant fatality. A US mid-year comparison (1993) was considered, however a more recent year was deliberately chosen to bolster the confidence in any differences discovered.

It is also most plausible that the risk to USAF motorcyclists was understated, even though deemed 'significant.' A quantitative fatality inference could not be determined because exposure surrogates, such as the number of licensed-drivers, were not available. One argument supporting USAF's greater risk is that USAF motorcycle crash factor analyses closely resembled published literature, thus giving credence to the overall analysis, including the soft indicators, which hinted at nearly twice the US fatality risk. Second is the predilection for riding, and thus fatality, among male youth, which comprised the preponderance of the USAF population. Thus, the risk of motorcyclist fatality among airmen was likely greater than among the general US population. Regardless, USAF (if not all military) motorcyclists clearly present an intervention opportunity.

It is important to note that fatal MVCs are rare, and more so among airmen. In an unknown number of MVCs, functioning seatbelts prevented the crash from becoming a case event, thus hiding precedent risk factors. These same circumstances are present in US MVCs, making comparisons between the two populations appropriate. However, the prevalence of at-risk behavior – the targets of intervention – is exponentially greater than was 'caught' by case events.

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Chapter 5

Conclusions

There are risks and costs to a program of action. But they are far less than the long-range risks and costs of comfortable inaction.

—John F. Kennedy

Our national security is in the hands of a well-disciplined, highly professional organization of young men and women. MVCs claim more of their lives than any other cause, including combat. Fortunately, far fewer lives are lost than expected despite the disproportionate representation by those most at risk. Regardless, we must do all we can to protect the very lives we have entrusted to protect our nation, and our way of life. The reduction in US MVC fatalities since 1980 is largely due to regulatory initiatives. Lower BAC limits, GDL systems, and nighttime driving curfews are current public health movements that are well suited for the military. Universal Department of Defense implementation of tailored versions of these three concepts as soon as possible will save many lives, a portion of them our treasured Armed Forces service members. Setting a BAC limit no higher than 0.05 percent is prudent. Though regulatory in nature, these initiatives powerfully play to the strengths of the military system: rules and regulations oriented, command and control organized, responsibility and accountability inherent. In addition, working toward consistent perfect occupant protection systems use, and the continued de-glamorization of alcohol must continue. A reduction in other unintentional injuries and fatalities would be a welcome side effect.

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